UCAR Visiting Scientist Program at the National Ice Center

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LONG TERM GOALS

The long-term goal of the University Corporation for Atmospheric Research (UCAR) Visiting Scientist Program at the National Ice Center (NIC) is to recruit the highest quality visiting scientists in the ice research community for the broad purpose of strengthening the relationship between the operational and research communities in the atmospheric and oceanic sciences.

The University Corporation for Atmospheric Research supports the scientific community by creating, conducting, and coordinating projects that strengthen education and research in the atmospheric, oceanic and earth sciences. UCAR accomplishes this mission by building partnerships that are national or global in scope. The goal of UCAR is to enable researchers and educators to take on issues and activities that require the combined and collaborative capabilities of a broadly engaged scientific community.

OBJECTIVES

The objectives of the UCAR Visiting Scientist Program at the NIC are:

- Manage a visiting scientist program for the NIC Science Center in support of the mission of UCAR.
- Provide a pool of researchers who will share expertise with the NIC and the science community.
- Facilitate communications between the research and operational communities for the purpose of identifying work ready for validation and transition to an operational environment.
- Act as a focus for interagency cooperation.

The NIC mission is to provide worldwide operational sea ice analyses and forecasts for the armed forces of the U.S. and allied nations, the Departments of Commerce and Transportation, and other U. S. Government and international agencies, and the civil sector. The NIC produces these analyses and forecasts of Arctic, Antarctic, Great Lakes and Chesapeake Bay ice conditions to support customers with global, regional and tactical scale interests. The NIC regularly deploys Naval Ice Center NAVICECEN Ice Reconnaissance personnel to the Arctic and Antarctica in order to perform aerial ice

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14. ABSTRACT

The long-term goal of the University Corporation for Atmospheric Research (UCAR) Visiting Scientist Program at the National Ice Center (NIC) is to recruit the highest quality visiting scientists in the ice research community for the broad purpose of strengthening the relationship between the operational and research communities in the atmospheric and oceanic sciences. The University Corporation for Atmospheric Research supports the scientific community by creating, conducting, and coordinating projects that strengthen education and research in the atmospheric, oceanic and earth sciences. UCAR accomplishes this mission by building partnerships that are national or global in scope. The goal of UCAR is to enable researchers and educators to take on issues and activities that require the combined and collaborative capabilities of a broadly engaged scientific community.

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observation and analysis in support of NIC customers. NIC ice data are a key part of the U.S. contribution to international global climate and ocean observing systems.

APPROACH

The UCAR Visiting Scientist Program works with participating Federal agencies to recruit scientific visitors and recent PhDs who are interested in conducting applications-oriented research and product evaluation of relevance to the NIC ice-monitoring mission. The UCAR visiting scientists are a source of expertise for the NIC as well as mentors to the recent PhDs.

Current participating agency representatives are:

Dr. Michael VanWoert: NIC Chief Scientist
Dr. Ted Maksym: UCAR Postdoctoral Fellow
Dr. Joerg Haarpaintner: UCAR Postdoctoral Fellow
Mr. Michael Chase: Product Development/ Programming Support/Web development
Mr. Phil Hovey: NOAA Physical Science Technician

Other agency representatives:

Dr. Waleed Abdalati: NASA program Sponsor
Dr. Juanita Sandige: NRL Stennis Space Center program sponsor

WORK COMPLETED

The primary mission of the NIC science team is to develop and improve tools that enhance the capabilities of the NIC in providing global and regional ice analysis and forecasts. Within this mandate are the development of new remotely sensed products, sea ice nowcast and forecast models, and the validation and improvement of these and other existing products, such as the Polar Ice Prediction System (PIPS). In the past year the science team has engaged in several inter-related activities either directly sponsored by or of interest to ONR that explicitly address this mission. These include:

- Development of an operational sea ice model for the marginal ice zone (MIZMO). This model can be either a stand-alone model or integrated into PIPS.

- NIC sponsored research cruise (ALTEX) aboard the USCGC Healy. This included a SeaWinds/QuikSCAT validation study for the development of new ice mapping algorithms. Such algorithms may be useful for routine ice analysis, PIPS initialization, or as a forcing data set for MIZMO. In-situ and visual ice measurements were conducted to support the validation of MIZMO.

- A forecast verification study of PIPS.

Operational Modeling of the Marginal Ice Zone

MIZMO is a free drift sea ice model explicitly designed for use in the marginal ice zone (MIZ). The sea ice model (MIZMO) was originally developed as a frazil/pancake growth model for investigation of thermohaline convection in the Greenland Sea (Toudal et al.). It is currently being adapted for use

as an operational ice model in collaboration with Drs. Leif Toudal of the Denmark Technical University (DTU) and Max Coon of Northwest Research Associates (NWRA).

Operational modeling of the marginal zone is difficult due to highly variable meteorological and oceanographic conditions, complex ice growth processes, and large and difficult to predict ocean heat fluxes. MIZMO handles these complexities by driving the ice growth with assimilated satellite observations (currently from the special sensor microwave imager instruments (SSM/I)). Ice drift is computed using winds provided by the Naval Operational Global Atmospheric Prediction System (NOGAPS) and currents from the Polar Ice Prediction System (PIPS). Observed ice concentrations from SSM/I imagery are then compared to model concentrations to provide a measure of ice growth or melt. New ice is apportioned between frazil and pancake ice by a simple parameterization scheme (Alam and Curry). Providing an accurate modeled ice distribution relies primarily on proper treatment of the ice drift and ice growth/redistribution parameterizations.

The following work has been completed on this project:

- MIZMO was installed as an experimental product producing automated daily analysis for four regions of interest – The Barents, Bering, and Greenland seas and the Sea of Okhotsk. Forcing data, including NOGAPS winds, PIPS currents, and PIPS ice thickness are now processed and ingested automatically. Results will be posted on a secure web-site so that all collaborators can readily access model results.

- Free drift drag coefficients and turning angles for driving the model have been determined for the Bering and Barents Seas. Individual ice floes were tracked using a combination of RADARSAT and optical line scanner (OLS) visible and infrared imagery.

- Validation of MIZMO has been conducted for the period of Sept-Nov, 2001 for the Barents Sea. Model predictions were compared to a suite of observations and products – SSM/I partial ice concentration retrievals, RADARSAT imagery, NIC ice charts, and field observations from the ALTEX cruise.

- An ocean heat flux module was developed. Heat flux derived from the SSM/I-based ice growth will be used to tune the model physics by comparison with prognostic heat flux calculations.

Healy Science Cruise (ALTEX)

The first NIC sponsored research cruise aboard the newly commissioned USCGC Healy was conducted in the Barents Sea during October and November 2001. Activities focussed on the collection of shipboard active/passive microwave sea ice measurements with coincident in situ characterization of the ice cover. Specific goals of the cruise were: 1) to develop and validate sea ice mapping algorithms using satellite scatterometer data (SeaWinds on QuikSCAT), 2) collect field observations of ice conditions for the validation of MIZMO, 3) improve sea ice mapping algorithms using satellite radiometer data, and 4) collect sea ice observations for SAR validation. In situ data of ice and snow properties and microstructure was collected at 17 stations in conjunction with shipboard scatterometer and radiometer measurements. Visual characterization of the ice conditions was made at 36 sites and during 2 helicopter reconnaissance flights.

RESULTS

Operational Modeling of the Marginal Ice Zone

Model results for autumn, 2001 in the Barents Sea compared well with a suite of validation data (RADARSAT, SSM/I, Ice charts, and shipboard observations). Ice type distributions from SSM/I partial concentration retrievals were reproduced well (Figure 1). For the date shown, NIC ice charts show the northern extent of first-year ice to be better represented by the model than SSM/I, suggesting that the model may be useful for improving ice type classification with passive microwave sensors. The model performed particularly well at capturing transient events, such as rapid production of frazil and pancake ice (Figure 2). For this particular growth event, however, the model predicts frazil ice formation a day later than was observed in the RADARSAT image (corroborated by field data). This is because of the weak microwave response of frazil ice.

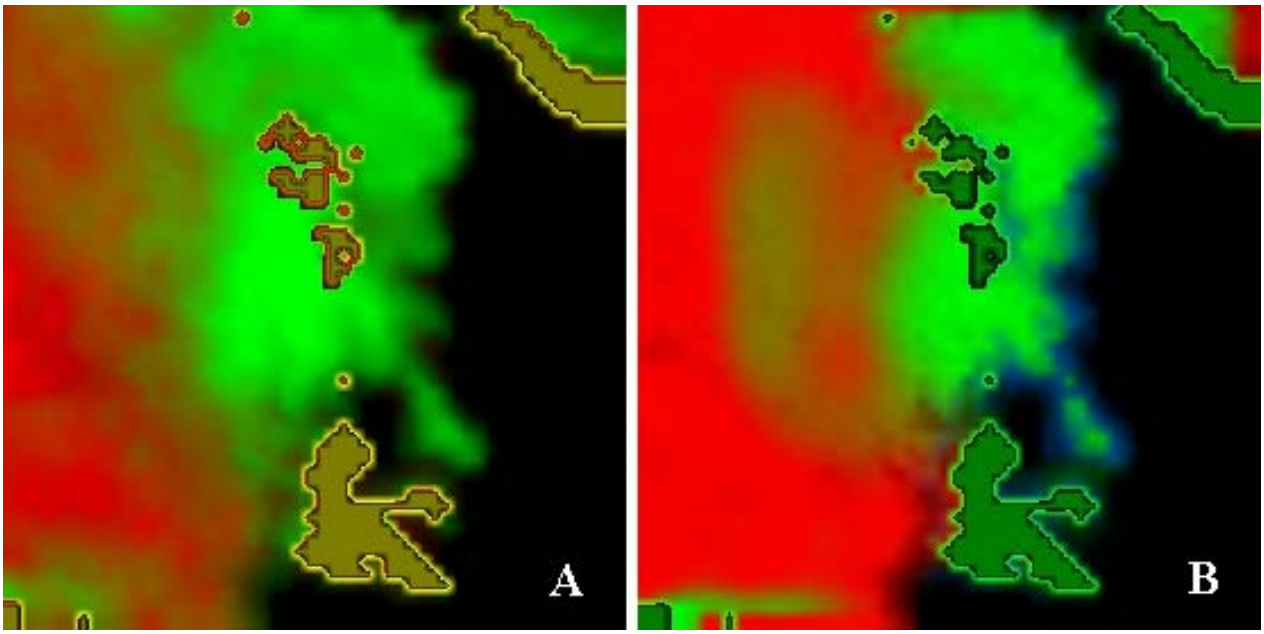

Figure 1. Comparison of SSM/I partial concentrations (a) and model prediction (b) for November 6, 2001. Colors indicate predominant ice type; multiyear ice is red, young ice is green, and frazil is blue. Svalbard is in the lower middle of the image; North is to the left. The model compares more favorably with NIC ice charts than SSM/I retrievals for this period.

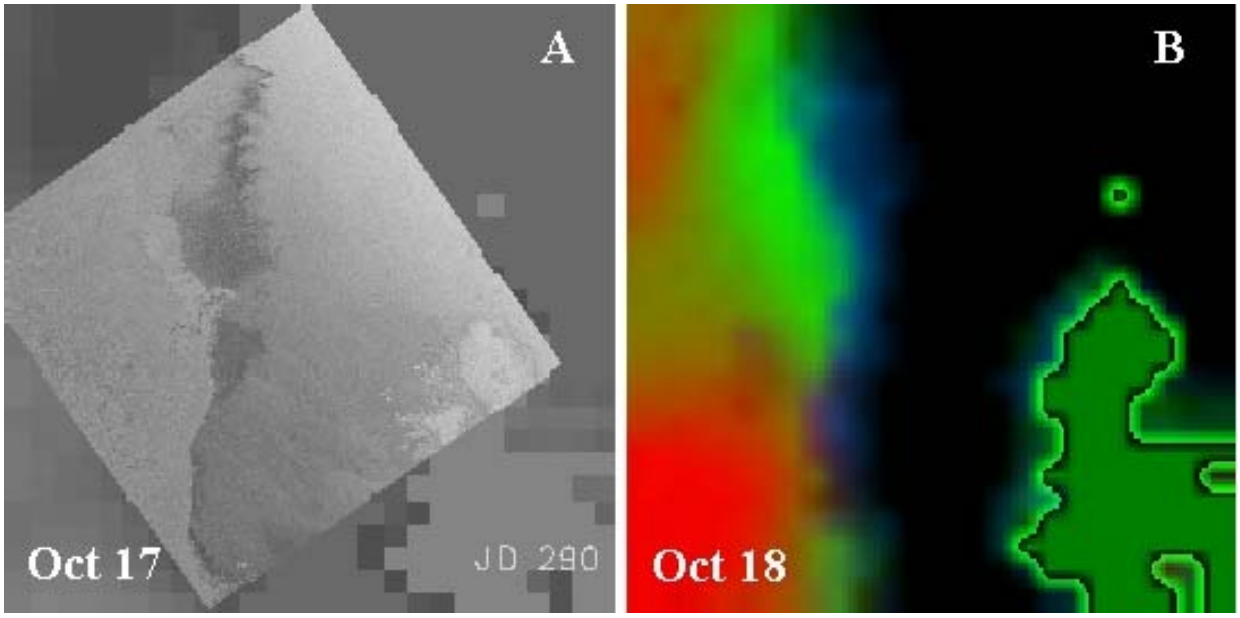

Figure 2. RADARSAT image for October 17, 2001 (a) and model prediction for October 18, 2001 (b) for a frazil/pancake growth episode observed during the ALTEX cruise. Svalbard is in the lower right corner; North is to the left. The frazil event (dark area in center of RADARSAT image) is well predicted, although it is detected a day late due to the weak SSM/I signature.

It was found that robust simulation of ice conditions will require both spatially or temporally varying drag coefficients and ensemble model predictions. Drag coefficients determined from observed ice drift showed marked variation from region to region and seasonally. This will necessitate regional 'tuning' of the model. For example, using the drag law determined specifically for the spring in the Bering Sea produced excessive ice transport through Bering Strait in winter. Furthermore, the high degree of variance in the observed ice drift suggests that useful operational ice analysis can best be achieved through ensemble model predictions.

Forecast Validation of PIPS

The NIC relies upon PIPS to aid in producing its 24-hour sea ice forecasts. The areas of interest to NIC customers are generally in areas of high variability such as the MIZ where prediction of ice conditions is difficult. To assess the reliability of PIPS for producing these products, the 24-hour forecast skill was determined for period June 1, 2000 - May 31, 2002. While the skill score relative to a climatological reference was high (>0.93, relative to a maximum score of 1.0), the skill was significantly lower relative to a persistence forecast. The skill was greater than 0 for all months except the freeze-up months of November - February. The variability was greatest near the marginal ice zone (MIZ) suggesting that ice growth during the winter months at the MIZ may not be properly parameterized in PIPS.

IMPACT/APPLICATIONS

Results of the marginal ice zone model (MIZMO) suggest that it is potentially a valuable aid for ice analysts in providing accurate determinations of current ice conditions. Specifically, it may provide an improved SSM/I ice type classification product and an estimate for ice thickness where currently no

accurate means are available. Extension of the model to include forecast capabilities could potentially provide an improved forecast relative to PIPS since the ice growth parameterizations are explicitly designed for the MIZ and are inherently flexible. Design of MIZMO is being guided to permit either in suite operation or full integration into PIPS.

RELATED PROJECTS

ONR grant N00014-00-C-0194, "Sea Ice Model for the Marginal Ice Zone to be used by NIC", Max Coon, PI, NWRA. Max Coon and Leif Toudal of DTU are carrying out much of the model development.

NRL grant number N00173-01-MP-00093, "Arctic Sea Ice Field Validation Campaign", Son Nghiem, PI, Jet Propulsion Laboratory. Several NIC personnel participated in sea ice measurements aboard the USCGC Healy to support QUIKSCAT validation and to obtain data for validation of MIZMO.

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